COAL CREEK FISHERIES MONITORING STUDY NO. IX

AND

FOREST-WIDE FISHERIES MONITORING - 1990

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ABSTRACT

This is the ninth year of data documenting trends in fish populations and aquatic habitat characteristics in the Coal Creek Drainage. Westslope cutthroat and juvenile bull trout population estimates remained similar at the Coal Creek sites during 1990. Cutthroat trout were present in both the Elk and Goat creek electrofishing sections. Limited numbers of eastern brook trout were also present in Elk Creek, while a substantial brook trout population exists in Goat Creek. We have observed large annual fluctuations in estimated juvenile bull trout numbers in the South Fork of Coal Creek compared with the North Coal estimates. We believe the magnitude of fluctuation in bull trout populations may be related to channel instability in the vicinity of the electrofishing section. Electrophoretic analysis during 1989 detected two bull trout/eastern brook trout hybrids in a sample of 26 fish from Goat and Lion creeks in the Swan River Drainage. Bull trout spawning escapement during 1990 appeared lower than previous years in all contract reaches. Overall, the 1990 run was average in the North fork below average in the Middle Fork and average in the Swan River Drainage. We detected significant changes in the median percentage of streambed gravel smaller than 6.35 mm at several contract sites. This size class increased significantly ($p< 0.05$) between the 1989 and 1990 sampling at the Hungry Horse Creek site. All other significant changes were decreases. Habitat enhancement efforts in the South Fork of Coal Creek resulted in some redistribution of streambed gravels. We observed bull trout spawning in an area of newly deposited gravel beside one of our enhancement structures. Juvenile bull trout populations decreased in this treatment section while increasing in both our control and other treatment sections. Westslope cutthroat trout population estimates remained similar in our control section, while decreasing in both treatment sections. We are unable to say whether the enhancement efforts are effective with only a short period of information. We documented extensive areas of high embeddedness and channel instability in the Dodge Creek Drainage. Most of the problem stems from the 1964 flood event. Similar degraded conditions are evident downstream in Granite Creek. We also noted several minor BMP departures during our surveys.

INTRODUCTION

This report contains information on the continued assessment and monitoring of fish populations and instream habitat in the upper Flathead River Drainage. The study's primary purpose is to document annual trends in fish population and habitat parameters. In a separate study, we are comparing fisheries variables with information on development in the watershed to show if and how forest management activities are affecting water quality and fisheries.

The Department of Fish, Wildlife and Parks (DFWP) initiated the original study in 1981, funded by Flathead National Forest (FNF) (Shepard and Graham 1982). Work continued through 1982 (Shepard and Graham 1983a), resulting in an ongoing data collection program (Shepard and Graham 1983b) for examining fluctuations in fisheries variables resulting from both natural and management related causes.

During 1983 and 1984, the study focused mainly on the Coal Creek drainage. FNF contracted the Cooperative Fisheries Research Unit at Montana State University (MCFRU) to complete this work. The original monitoring program continued along with preliminary examination of the relationship between substrate composition and bull trout embryo survival to emergence (Weaver and White 1985). The 1985 study, again conducted by DFWP, involved only a portion of the program including estimation of late summer fish abundance, evaluation of substrate composition in important spawning areas and assessment of the 1985 bull trout spawning run (Weaver and Fraley 1985). The Montana Department of Fish, Wildlife and Parks completed these activities annually from 1985 through 1989, using existing methods and sampling sites allowing comparable results (Weaver and Fraley 1986, 1988, Weaver 1989, 1990).

Under the current contract (Table 1), DFWP estimated late summer fish abundance for two sections in the Coal Creek Drainage and two Swan River tributary sections. We counted bull trout spawning sites in the Coal Creek Drainage and two Middle Fork tributaries. Biologists evaluated streambed substrate composition in four important bull trout spawning areas, one adfluvial westslope cutthroat trout spawning area and one adfluvial rainbow trout spawning area. Field crews identified all major stream features (MDFWP 1983) in Dodge and upper Granite creeks. The 1990 contract also included an evaluation of the habitat enhancement project in the South Fork of Coal Creek. Researchers conducted fieldwork from July 1990, through October 1990, as a cooperative effort by DFWP and FNF personnel. As in past years, we used existing sampling locations and methods ensuring comparable results.

In addition to the activities reported, DFWP completed electrofishing estimates in eight tributary sections, bull trout redd counts in ten major spawning streams and westslope cutthroat

Table 1. Description of study sties and activities specified under the 1990 contract.

Drainage	Creek	Sampling Area Name	Location	Activity: Fish Abundance	Activity: Bull Trout Redd Count	Activity: Substrate Monitoring	Activity: Habitat Enhancement	Activity: Feature ID
North Fork Flathead								
	North Coal	South Fork Bridge	SW 1/4 Sec 24 T34N R22W	X	-	-	-	-
		N. Coal Coring site	NW 1/4 Sec 23 T34N R22W	-	-	X	-	-
		Monitoring Section	NE 1/4 Sec 30 T34N R22W downstream to NE 1/4 Sec 34 T34N R22W	-	X	-	-	-
	South Fork Coal							
		South Fork	NE 1/4 Sec 26 T34N R22W	X	-	X	-	-
		Lower rehab.	SW 1/4 Sec 26 T34N R22W	X	-	-	X	-
		Upper rehab.	SW 1/4 Sec 26 T34N R22W	X	-	-	X	-
		Monitoring Section	NW 1/4 Sec 34 T34N R22W downstream to NW 1/4 Sec 30 T34N R22W	-	X	-	-	-
	Mathias	Monitoring section	SW 1/4 Sec 5 T33N R22W downstream to NW 1/4 Sec 34 T34N R22W	-	X	-	-	-
Middle Fork Flathead								
	Granite	Coring site	SW 1/4 Sec 7 T28N R13W	-	X	-	-	-
	Dodge	Sediment contrib. zone	SE 1/4 Sec 19 T29N R13W downstream to S 1/2 Sec 18 T29N R14W	-	-	-	-	X
	Morrison	Monitoring section	NW 1/4 Sec 9 T28N R13W downstream to NE 1/4 Sec 9 T27N R13W	-	X	-	-	-
South Fork Flathead								
	Hungry Horse	Lower coring site	NW 1/4 Sec 22 T30N R18W	-	-	X	-	-
Swan River								
	Goat	Coring site	SE 1/4 Sec 10 T23N R17W	X	-	-	-	-
	Jim	888 Bridge	NW 1/4 Sec 32 T22N R17W	-	-	X	-	-
	Elk	9591 Bridge	NE 1/4 Sec 16 T20N R17W	X	-	X	-	-
Tally Lake R.D.								
	Fish	Ashley Bridge	NW 1/4 Sec 15 T28N R24W	-	-	X	-	-

trout redd counts in six important spawning streams. We completed substrate sampling in 12 other spawning areas during the 1990 season. Results of these additional 1990 monitoring efforts in the Flathead Drainage will be presented in other reports.

METHODS

Fish Abundance Estimates

We made juvenile fish abundance estimates by electrofishing 150 m sections in selected tributaries to the North Fork of the Flathead and the Swan rivers. We used the same sections sampled during past years and equipment and procedures described by Shepard and Graham (1983b).

We calculated juvenile bull trout (Age I+) population estimates for important rearing ares in the North and South forks of Coal Creek, Elk Creek and Goat Creek. We estimated cutthroat trout populations (Age I+) in both Coal Creek sections. We compared these estimates with records from electrofishing during previous years to assess trends in fish abundance. We applied the technique of assessing population fluctuation described by Platts and Nelson (1988). These authors defined the maximum relative fluctuation (M_s) as the percentage difference between the highest and lowest value of each population statistic relative to the lowest value:

$$M_s = \frac{X_{max} - X_{min}}{X_{min}} \times 100;$$

X_{max} = largest annual value and X_{min} = smallest annual value.

This statistic related the largest observed change to the smallest observed value during the study period, and gives an indication of the magnitude of potential for change of each population statistic evaluated.

They used average relative fluctuation (A_s) to describe the magnitude of change in each population statistic with respect to the mean value of that statistic over the course of the study:

$$A_s = \frac{X_{max} - X_{min}}{X_{avg}} \times 100;$$

X_{max} and X_{min} are as above and X_{avg} = average value over the entire study period.

Total biomass (B_t), the estimated total trout weight, and aerial biomass (B_a), the estimated trout weight per unit surface area, were computed as:

$$B_t = \hat{N}W \text{ and } B_a = \frac{B_t}{lw};$$

$\hat{N}$ = estimated trout population size. W = mean trout weight, l = length of the stream section, and w = mean width of the study stream.

In conjunction with the 1989 electrofishing efforts, we began to test juvenile bull trout populations for hybridization with eastern brook trout in Swan River tributaries. We retained 25 bull trout from our Goat Creek section for electrophoretic analysis.

Bull Trout Spawning Site Inventories

We conducted bull trout spawning site inventories in sections of Coal, Morrison, and Granite creeks recommended for annual monitoring by Shepard and Graham (1983b). We also surveyed Mathias Creek. Preliminary bull trout spawning surveys indicated final redd counts could begin during the last week of September. Final surveys were conducted by crews walking down the channel. We enumerated, classified, and located all observed redds as described by Shepard and Graham (1983b). We compared counts to past surveys of the same tributary section and by the major drainages as a whole, to evaluate trends in spawner escapement.

Spawning Area Substrate Composition

We collected substrate samples from known westslope cutthroat and bull trout spawning areas in the upper Flathead Drainage to document trends and to evaluate potential fry production. Important bull trout spawning areas sampled included those in North Coal, South Fork Coal, Elk and Jim creeks. Westslope cutthroat spawning areas sampled included Hungry Horse Creek. The rainbow spawning area in Fish Creek was also sampled.

We used standard 15.24 cm hollow core sampler following procedures described by Shepard and Graham (1982). We placed samples in labeled bags and transported to the Flathead National Forest Soils Lab in Kalispell for analysis. After drying, each core sample was passed through the following sieve series:

76.1 mm	(3.00 inch)
50.8 mm	(2.00 inch)
25.4 mm	(1.00 inch)
19.0 mm	(0.75 inch)
12.7 mm	(0.50 inch)
9.52 mm	(0.38 inch)
6.35 mm	(0.25 inch)
4.76 mm	(0.19 inch)

2.00 mm	(0.08 inch)
0.85 mm	(0.03 inch)
0.42 mm	(0.016 inch)
0.063 mm	(0.002 inch)
Pan	(<0.002 inch)

Material retained on each sieve was weighed and the percent dry weight in each size class calculated and summed cumulatively. The median percentage smaller than 6.35 mm in each spawning area was compared with information collected during the previous year using Mann-Whitney tests. We estimated average survival to emergence in each of the spawning areas sampled using field developed predictive equations for westslope cutthroat and bull trout (MDFWP unpublished data). The equation used for cutthroat trout was:

$$\% \text{ survival} = -1.3096244\ (S_{6.35}) + 71.35$$

$(S_{6.35})$ = % smaller than 6.35 mm;

The equation used for bull trout was:

$$\% \text{ survival} = -1.3962821\ (S_{6.35}) + 78.095$$

Habitat Enhancement

An evaluation of the 1988 habitat enhancement efforts in the South Fork of Coal Creek was included as part of the 1990 work. We electrofished both sections as previously reported and compared these estimates with pretreatment estimates.

We selected these sections for several reasons: (1) both fish species were present throughout this area and a 150 m section has been electrofished annually since 1985, providing a period of record for assessing natural population fluctuations; (2) streamside timber in this area has been harvested, limiting potential for natural recruitment of large woody debris; (3) the proximity of an undeveloped timber stand north of road 1686 provided quick access to raw materials; and (4) topography of the area allowed selection, transport and placement of raw materials with minimal impact to the timber stand, riparian zone, and stream channel itself.

We used a replicated treatment-control study design and assumed natural population fluctuations will be similar in both treatment and control sites. Treatment involved placement of whole trees with root wads attached at five locations in each section. Trees were secured in position as recommended by Seehorn (1985).

Stream Feature Identification

All major stream features (MDFWP 1983) in the Dodge Creek drainage were located and classified during surveys of the total channel area in each of the major forks. Side drainages were included in an effort to examine all areas in the sediment contributing zone. We pace located major features during field surveys and later marked these on a map. We prepared a narrative listing of major stream features beginning in the headwaters in section 19 and proceeding downstream to the wilderness boundary on Granite Creek. We included a list of major problem areas where there is some potential for corrective or stabilizing activities in the management recommendations section.

RESULTS AND DISCUSSION

Fish Abundance Estimates

The 1990 juvenile bull trout population estimates for the Coal Creek sections remained within the range observed during past years (Table 2). Substrate scores during 1990 were 13.2 and 11.5, respectively, in the North Coal and South Fork sections. The probability of first pass capture ($\hat{p}$) during this year's electrofishing in the South Fork of Coal was slightly lower than the recommended level of 0.60 (Shepard and Graham 1983b). Generally, when we handle a substantial number of fish during an effort, we will make a third electrofishing run if this level of p is not obtained. Since we had an adequate p for cutthroat trout in this section after two passes and a considerable period of record exists for comparison, the information to be gained by a third pass did not justify increasing the level of the 1990 effort.

Westslope cutthroat trout population estimates for the Coal Creek drainage in 1990 appeared quite similar to past years (Table 3). Both sections support substantial populations. We observed several young-of-the-year westslope cutthroat trout in the North Coal section again this year. This suggests that spawning takes place in the general vicinity of the 317 bridge, although high flows have prevented us from locating actual spawning sites. We obtained a low p for westslope cutthroat during this year's electrofishing in the North Coal section, however no third pass was made for the reason discussed previously.

Time-trend information collected during our nine year study period shows considerable fluctuations in fish population statistics (Table 4). We observed a maximum relative change of over 400 percent in bull trout numbers in the South Fork of Coal Creek electrofishing section; the mean relative fluctuation for this section is over 150 percent. Juvenile bull trout numbers in the North Coal electrofishing section have fluctuated about half as much during the same time period. We believe the larger fluctuations in juvenile bull trout population statistics for the South Fork of Coal Creek stem from the unstable nature of the stream channel in this area.

Our electrofishing section in the South Fork is located near the downstream end of an area where past land management activities resulted in a major channel changes. This area was clearcut and a length of channel was artificially straightened and deepened in the early 1970s to eliminate braiding and low summer flow problems. The channel area around the North Coal electrofishing section appears much more stable. Although roads are located on both sides of the stream above this site, the riparian area remains intact.

These observations suggest channel instability may result in larger fluctuations in juvenile bull trout numbers. The long-term effects

Table 2. Summary of annual population estimates for Age I and older bull trout calculated from electrofishing in the sections specified for monitoring during 1990.

Drainage	Creek	Section	Date	$\hat{N}$	95% CI	$\hat{p}$
North Fork Flathead						
	North Coal	317 Bridge	8/04/82	17	±9	.60
			8/25/83	18	±3	.78
			8/29/84	48	±12	.63
			8/27/85	41	±5	.77
			9/03/86	29	±12	.59
			8/05/87	47	±17	.56
			8/16/88	39	±5	.69
			9/08/89	44	±18	.54
			8/27/90	33	±3	.65
	South Coal	Section 26	8/28/85	62	±8	.74
			8/06/87	12	±2	.48
			8/08/88	24	±2	.85
			9/29/89	14	±2	.83
			8/24/90	49	±17	.57
Swan River						
	Elk	9591 Bridge	9/21/89	44	±7	.71
			9/20/90	86	±13	.67
	Goat	Section 10	8/11/87	66	±6	.79
			8/22/88	32	±4	.80
			8/30/89	34	±2	.86
			9/10/90	10	±0	1.00

Table 3. Summary of annual population estimates for Age I and older cutthroat trout calculated from electrofishing in the sections specified for monitoring during 1990.

Drainage	Creek	Section	Date	$\hat{N}$	95% CI	$\hat{p}$
<u>North Fork Flathead</u>						
	North Coal	317 Bridge	8/04/82	40	±7	.72
			8/25/83	27	±4	.82
			8/29/84	48	±12	.50
			8/27/85	51	±36	.45
			9/03/86	40	±11	.64
			8/05/87	63	±2	.91
			8/16/88	51	±9	.69
			9/08/89	51	±9	.69
			8/27/90	39	±8	.53
	South Coal	Section 26	8/28/85	63	±35	.33
			8/06/87	43	±4	.47
			8/08/88	43	±3	.83
			9/29/89	59	±10	.67
			8/27/90	41	±4	.82
<u>Swan River</u>						
	Elk	9591 Bridge	9/21/89	*		
			9/20/90	21	±16	.61
			8/11/87	*		
	Goat	Section 10	8/22/88	*		
			8/30/89	*		
			9/10/90	10	±4	.71

Table 4. Observed maximum and mean annual fluctuations in estimated juvenile bull and westslope cutthroat trout population sizes, total and area biomass and mean weights and lengths for electrofishing sections in the Coal Creek drainage during the period 1982 through 1990. Fluctuations are expressed as percentages of the minimum or average yearly values (maximum and mean fluctuations, respectively).

		% Fluctuation									
				Biomass							
		Number		Total (g/section)		Aereal (g/m^2)		Mean Weight (g)		Mean Length (mm)	
Creek - Section	Years of Data	Max	Mean	Max	Mean	Max	Mean	Max	Mean	Max	Mean
				Bull Trout							
Coal - South Fork bridge (north Coal)	9	182	88	178	99	200	100	118	79	36	25
South Fork Coal (section 26)	5	417	155	354	142	313	130	137	88	50	41
				Cutthroat Trout							
Coal - South Fork bridge	9	133	79	112	78	154	107	101	66	42	34
South Fork Coal	5	54	44	131	89	109	76	232	126	23	20

of an increase in the magnitude of population fluctuations within any given stream segment can not be adequately assessed with existing data. However, this information supports the selection of bull trout as an indicator species in monitoring for potential land management effects. Continuing examination of population fluctuations may yield some index value for assessing effects of land management on juvenile bull trout rearing.

The fact that westslope cutthroat trout populations in the same sections have not responded similarly is possibly due to differences in habitat preferences between the two species. Juvenile bull trout are extremely substrate oriented; westslope cutthroat trout typically occupy positions higher up in the water column. Change in streambed materials would affect the substrate oriented species more strongly.

Activity assessment and risk analysis information has been collected as part of the Flathead Basin Commission's cooperative forest practice study. As this information becomes available, fluctuations in the various fish population statistics may become more meaningful in determining how various land management activities or specific forest practices may or may not relate to the fishery. The importance of a continuous period of record can not be over-emphasized. We recommend that FNF select a stream section above which no development has occurred or is planned. This site should be annually monitored on a long-term basis to obtain a data set comparable to what is presented in Table 4. This information from an unmanaged watershed will provide better information on population fluctuations.

We electrofished this particular section in Elk Creek for the second consecutive year; minimal directly comparable data are available. This year's juvenile bull trout estimate (Table 2) appeared closer to, but still less than the number reported by Leathe et al. (1985) for this reach of Elk Creek (255/300 m). The 1982 section was located approximately 1.5 km downstream from the current site. The substrate score for this section was 12.1 during 1990. We observed cutthroat trout in the Elk Creek section during both years (Table 3). During 1989, the electrofishing crew handled only 12 cutthroat trout; this year we captured enough fish to calculate a population estimate. We observed young-of-the-year cutthroat trout during both years, suggesting spawning occurs in the vicinity of the 9591 bridge.

Researchers have electrofished the Goat Creek section annually since 1987. The 1990 estimate for juvenile bull trout was considerably lower than in past years (Table 2). A section of the channel including the upper end of our electrofishing section is actively migrating. The field crew first noted this change during this year's electrofishing. Although instream cover is still available, substrate embeddedness has increased. Substrate score for the Goat Creek section has dropped from 10.8 in 1988 to 10.2 in

1989 and 9.5 during 1990. Surveyors noted no apparent reason for the channel migration during bull trout redd counts through this area. We took a sample of 25 juvenile bull trout from this section in 1989 for genetic analysis. This may have contributed to the low estimate this year.

We observed cutthroat trout annually in the Goat Creek section, but could not calculate population estimates based on the low number of fish captured prior to the 1990 effort (Table 3). Even through the field crew captured enough fish to calculate the estimate this year, the cutthroat trout population in this portion of Goat Creek remains at a low level. Leathe et al. (1985) reported rainbow trout populations in both Elk and Goat creeks.

Both Elk and Goat creeks contained eastern brook trout. We captured at least four age classes of brook trout (Age 0 - Age III+) in Goat Creek, obtaining an estimate of 16±2 Age I and older fish. We observed three age classes of brook trout in Elk Creek (Age I - Age III+) resulting in an estimate of 11±4 Age I and older fish. Past electrophoretic analyses confirmed that bull trout/eastern brook trout hybrids were present in Goat and Lion creeks. Several fish handled during the 1990 estimate in Elk Creek appeared to be hybrids, however we have conducted no genetic testing on Elk Creek fish to date. We recommend genetic samples be collected during future electrofishing efforts in streams where both bull trout and brook trout occur. However, we recommend these collections be made outside the sections annually electrofished for population estimates.

Bull Trout Spawning Site Inventories

We identified 55 bull trout redds in the Coal Creek drainage during 1990. Twenty-nine of these were located in the annual monitoring section while field crews observed 13, 9, and 4 redds in North Coal, South Fork Coal, and Mathias creeks, respectively (Table 5). In the Middle Fork drainage, Morrison and Granite creeks contained 24 and 21 bull trout redds, respectively (Table 5).

We completed the 1990 bull trout redd counts between September 25 and October 16. Based on the number of redds observed in all areas selected for annual monitoring (Shepard and Graham 1983b), the 1990 spawning run appeared average in the North Fork, 46 percent below average in the Middle Fork and average in the Swan River drainage. North Fork tributary monitoring areas have averaged 229 redds during 11 years of annual counts (1979-1989). The 1990 total of 228 suggests an average run in the North Fork drainage. Although Coal Creek contained approximately one-third fewer redds than normal this year, above average runs in Big and Trail creeks made up this difference.

Table 5. Summary of annual bull trout redd counts by section for the streams specified f inventory during 1990.

Creek	Section	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Coal													
	Above the South Fork	--	4	7	25	13	3	--	22	--	10	29	13
	Below the South Fork (monitoring area)	38	34	23	60	61	53	40	13	48	52	50	29
S. Fork Coal		--	19	24	9	3	5	--	4	--	24	33	9
Mathias		--	10	10	17	12	8	--	10	--	19	9	4
Granite		14	34	14	34	31	47	24	37	34	32	31	21
Morrison		25	75	32	86	67	38	99	52	49	50	63	24

counts in Middle Fork tributary monitoring areas have averaged 144 redds annually during the same 11-year period. The 1990 total of 77 redds is 46 percent below this average figure. We recorded the lowest totals on record in Morrison and Lodgepole creeks this year. We also observed lower than normal redd numbers in the two other Middle Fork monitoring streams. During 1987 and 1988, low flows and an actively migrating channel combined to form a migration barrier preventing adult bull trout from using the portion of Morrison Creek above km 5.5 (Weaver 1989). This year we captured no Age 0 or Age I bull trout in our electrofishing section at km 18.5. Field crews observed 28 and 18 redds respectively above km 5.5 during 1989 and 1990 redd counts. Higher flows probably allowed better fish passage during these years; however, this problem may occur again in future low flow years.

Combining redd numbers from the North and Middle fork monitoring areas gives an index of total bull trout spawning escapement from Flathead Lake. This total has averaged 373 redds over the last 11 years. The 1990 count of 305 is 18 percent less than average. There are unmonitored sections in several of these streams, as well as other streams which are utilized by spawning bull trout. Our numbers do not represent the total annual spawning run. We estimate our annual counts represent around 35 percent of the annual Flathead Lake spawner escapement.

Annual redd counts in Swan River tributary monitoring areas have averaged 253 over the last 8 years (1982-1989). The 1990 total of 263 is 4 percent above the average number observed. Although the current count in Swan River tributaries is above average it is considerably lower than the last three years. Since 1985, bull trout redd counts in the Swan increased annually until this year.

Spawning Area Substrate Composition

Field crews have sampled spawning gravel composition in both forks of Coal Creek annually since 1985 (Table 6). We also identified sediment sources in both watersheds during 1988 surveys (Weaver 1989). As part of the Flathead Basin Commission's cooperative study, researchers developed an activity assessment index (Sequoia) for third order watersheds (Potts and McInerny 1990). Combining results from these efforts yields considerable insight into sediment modeling and dynamics in upper Coal Creek.

Spawning area gravel sampling in North Coal Creek suggests considerable fluctuations occur here regularly (Table 6). We observed a significant decrease ($p < 0.10$) in the median percentage of material smaller than 6.35 mm between 1985 and 1986. Sampling results showed no significant change between 1986 and 1987 and a significant increase ($p < 0.05$) in fine material between 1987 and 1988. We observed no change between 1988 and 1989 and a significant decrease ($p < 0.10$) between 1988 and 1989. The current

Table 6. Summary of annual median percentages of streambed material smaller than 6.35 mm in diameter, Mann-Whitney test results and mean predicted embryo survival to emergence, based on core sampling in known spawning areas.

Spawning Area	Year	n	Median % < 6.35 mm	Test[1] results	Mean predicted survival (%) WCT	Mean predicted survival (%) DV
North Coal	1985	12	34.9		26	30
				* ↓		
	1986	12	29.4		33	37
				NS		
	1987	12	30.2		31	35
				** ↑		
	1988	12	39.8		21	25
				NS		
	1989	12	37.8		21	24
				* ↓		
	1990	12	32.8		28	31
South Coal	1985	12	36.0		23	26
				* ↓		
	1986	12	31.8		30	34
				NS		
	1987	12	31.4		28	32
				NS		
	1988	12	32.1		30	34
				NS		
	1989	12	36.1		25	28
				NS		
	1990	12	33.6		27	31
Jim	1988	12	41.1		17	20
				** ↑		
	1989	12	50.3		7	9
				** ↓		
	1990	12	42.4		14	17
Elk	1989	12	37.6		23	27
				NS		
	1990	12	39.8		18	21
				NS		
Fish	1986	12	20.5		--	--
				** ↑		
	1987	12	32.8		--	--
				* ↓		
	1988	12	26.3		--	--
				** ↑		
	1989	12	34.2		--	--
				NS		
	1990	12	36.8		--	--
Hungry Horse	1986	12	27.8		34	--
				** ↑		
	1987	12	35.0		27	--
				NS		
	1988	12	34.8		25	--
				** ↓		
	1989	12	29.2		32	--
				** ↑		
	1990	12	36.0		25	--

sampling indicated a significant decrease ($p < 0.10$) between 1989 and 1990 (Table 6).

Timber harvest activities are occurring above our sampling station in North Coal Creek, including new road construction and major reconstruction during the early 1980s. Surveyors noted considerable natural erosion and slumping in the headwaters area as well as several management-related sediment sources (Weaver 1989). The Sequoia index for the northern fork of Coal Creek above our sampling station is 6.70 (Potts and McInerny 1990). This figure represents the percentage of the watershed disturbed by management activities during the last ten years. Predicted embryo survival has ranged from 21 to 33 percent for westslope cutthroat and from 24 to 37 percent for bull trout during the period of record (Table 6).

Streambed sampling data from the South Fork of Coal Creek suggests considerably less variability. We observed a significant decrease ($p < 0.10$) in fine material between 1985 and 1986 (Table 6). Sampling has shown no significant change in the annual median percentage of material smaller than 6.35 mm since this time.

During 1989, fall rains resulted in high stream flows during the scheduled sampling period. High water persisted through much of the winter. As a result, we completed the annual sampling in February and March, 1990. Although postponing coring until the following spring is not ideal, we believe results are more reflective than those obtained while flows are too high and site selection may be biased.

Surveyors observed major sediment contributing areas in the South Fork of Coal drainage above a series of relatively stable beaver dams. A large amount of sediment is currently stored in the channel behind these dams. This partially explains why we observed little variability. Also, no major land disturbing activities have occurred above our sampling station since we began monitoring. In fact, the Sequoia index value for the South Fork watershed above this point is 3.90 (Potts and McInerny 1990).

A large portion of the material stored behind the beaver dams originated in a 1956 harvest unit. This fine material will likely impact spawning gravel downstream and show up in our sampling at some point after the dams fail. Consequently, we believe the ten-year recovery rate built into the Sequoia index may be inadequate and the index value for the watershed above the South Coal coring site is probably not valid. Predicted embryo survival ranged from 23 to 30 percent for westslope cutthroat and from 26 to 35 percent for bull trout during the period of record (Table 6).

This is the third year of annual sampling in Jim Creek at the crossing of Forest Road 888. A portion of the upper Jim Creek basin has recently been developed. Timber harvest and associated

road construction took place on private timberlands in the West Fork of Jim Creek during fall and winter, 1988.

The median percentage of material smaller than 6.35 mm during our initial sampling was 41.5 percent (Table 6). We collected these samples after the planned development, but prior to any runoff. A water quality monitoring program showed elevated turbidity levels below the disturbed area during spring runoff, 1989 (Water Quality Bureau 1990). A subsequent audit of best management practices identified several major departures associated with the West Jim sale (Ehinger and Potts 1990).

Our 1989 core sampling suggested a significant increase ($p < 0.05$) in fine material had occurred at the 888 bridge (Table 6). Crews also collected McNeil core samples immediately above and below the sale area in West Jim Creek as part of the Flathead Basin Commission's cooperative study. Samples collected above the sale area have shown no significant change. We observed no change in Lion Creek, the neighboring drainage paired for comparison. However, samples from just below the sale area indicated a significant increase ($p < 0.05$) had occurred. This observed increase is the largest annual change documented for a sampling area in ten years of sampling. We concluded that the observed change resulted from the development activity in West Jim Creek.

It is not possible to determine whether the change we noted at the 888 bridge resulted from the sale in West Jim Creek, but the timing and the magnitude of change appeared quite similar. This year's sampling suggests a significant decrease ($p < 0.05$) since the 1989 sampling. Levels of fine material are now quite similar to what we observed prior to the West Jim Sale (Table 6). Predicted embryo survival dropped to less than 10 percent for both westslope cutthroat and bull trout during 1989 (Table 6).

This is only the second year of sampling in Elk Creek. We saw no significant change in the percentage of material smaller than 6.35 mm between the 1989 and 1990 samplings (Table 6). Predicted embryo survival remained quite similar for both westslope cutthroat and bull trout (Table 6). The Sequoia index for Elk Creek above our sampling station is 0.00, indicating no disturbance in the watershed (Potts and McInerny 199). However, we know of major natural sediment sources and high levels of channel storage in Elk Creek below its upper fork. The Sequoia index does not consider natural sediment sources or other natural phenomena which may alter streambed conditions. Therefore, we feel that Elk Creek is not typical of spawning area streambed conditions in undeveloped watersheds in the Flathead Basin. Average gravel composition in spawning areas of undeveloped watersheds is 29.8 percent smaller than 6.35 mm (range 24.8 to 33.6; n = 7).

Field crews have sampled spawning gravel in Hungry Horse Creek annually since 1986. We have observed considerable fluctuations

(Table 6). Researchers had to relocate the sampling station in 1989 due to a channel change which resulted after district personnel placed fill material across a side channel along Forest Road 38. Predicted westslope cutthroat trout embryo survival has ranged from 25 to 34 percent during our period of record (Table 6). No bull trout spawning occurs in Hungry Horse Creek.

This is the fifth year of annual sampling in Fish Creek. This steam also shows considerable annual fluctuations in spawning gravel composition (Table 6). The 1990 sampling resulted in the highest median percentage of material smaller than 6.35 mm observed to date (Table 6). However, the 1990 median level was not significantly greater than what we observed in 1989.

Both the Sequoia index and H_2OY model output for Fish Creek were extremely high compared to other Flathead Basin tributaries. Over 22 percent of the watershed has been disturbed during the last ten years and current water yield is approximately 17 percent over natural (Potts and McInerny 1990). I would expect spawning gravel composition to be in much worse condition given these data. The fish species utilizing Fish Creek for spawning and rearing are generally rainbow-cutthroat hybrids; no predictive survival to emergence model is presently available.

Habitat Enhancement

All ten trees remained as placed through the 1990 runoff period. Field crews checked the area during high flows in May and early June, 1990. At the observed flows, it appeared that we could have placed several of the trees further out in the channel and still kept them in place. This would have provided more cover during extremely low flow periods. However, I do not recommend relocating any of the trees at this time.

We observed some redistribution of streambed material resulting from our activities. The upper treatment section contained noticeably more gravel and less larger material than prior to the test. Substrate score for this section declined from 13.2 in 1988 to 12.8 in 1989 and to 12.5 in 1990. During the 1989 redd counts we observed a spawning site associated with one of our trees. Streambed material here was too large for spawning prior to placement of the tree.

In 1990, the juvenile bull trout population estimate in the control section was approximately twice what it was prior to the test (Table 7). The lower treatment section was also higher (66 percent) but the juvenile bull trout estimate for the upper treatment section was approximately 18 percent less. We believe this may be due to the previously mentioned change in streambed materials from larger to smaller. Because of similar trends in estimated numbers at the control and the lower treatment site,

Table 7. Population estimates ($\hat{N}$) and densities (#/100m^2) for Age I+ westslope cutthroat and bull trout in sections of the South Fork of Coal Creek selected for habitat enhancement testing.

Section	Pre-treatment		First year post-treatment		Second year post-treatment	
	($\hat{N}$)	Density	($\hat{N}$)	Density	($\hat{N}$)	Density
			Westslope Cutthroat			
Upper	20±5	2.5	13±33	1.3	10±4	1.0
Lower	34±1	5.4	41±29	5.7	22±8	2.9
Control	43±3	4.4	59±10	5.8	41±4	3.6
			Bull Trout			
Upper	160±6	15.2	102±16	9.9	128±6	12.8
Lower	65±4	10.3	41±4	5.7	108±22	14.2
Control	24±2	2.5	14±2	1.4	49±17	4.4

treatment induced effects are not suggested. We previously discussed the large magnitude of population fluctuations for juvenile bull trout in the South Fork of Coal Creek. Perhaps we should set up a similar test in a section where juvenile bull trout populations appear more stable.

During the three year test period, westslope cutthroat trout have remained quite similar in the control section while a decline in both numbers and density is suggested for both treatment sections (Table 7). This divergence in the pattern of fluctuation generally indicates treatment induced effects (Platts and Nelson 1988). However, with the short period of record any firm interpretations are difficult.

Stream Feature Identification

These surveys showed highly unstable channel areas existed in the Dodge Creek Drainage (Appendix A). The vast majority of the problems observed were natural and resulted from the 1964 flood event. Sediment resulting from this event is still present in large amounts resulting in channel migration, deposition, and high embeddedness levels. Westslope cutthroat trout spawning area gravel composition in Dodge Creek appears to be seriously degraded. Dodge Creek appears to contribute to the high levels of fine material present in the bull trout spawning area in Granite Creek as well.

We also identified several management-related problems. Most were associated with older activities. However, we also noted several minor BMP departures associated with recent timber management activities (Appendix A).

RECOMMENDATIONS

Continuation of this monitoring program will allow a greater understanding of factors which limit fish populations in the upper Flathead Basin and how land management decisions may influence them. Based on findings in this and previous studies, we recommend the following work to be cooperatively completed by MDFWP and FNF:

1. Monitoring

   A. Continue monitoring fish populations in selected stream sections. Bull trout rearing streams with established electrofishing sections include Big, Coal, South Fork Coal, North Coal, Red Meadow, Whale, Trail Swift Ole, Morrison, Quintonkin, Elk, Goat, Lion, Squeezer, Piper, and Jim creeks. Established sections for monitoring westslope cutthroat populations include North Coal, South Fork Coal, Cyclone, Langford, Red Meadow, Swift, Akokala, Challenge, Hungry Horse, Margaret, Tiger, Lost Mare, Emery, McInernie, Felix, Harris, Logan, and Quintonkin creeks. Rainbow trout population-monitoring sections are located in Fish and Freeland creeks.

   B. Maintain annual measurement of substrate quality in both westslope cutthroat and bull trout spawning areas by core sampling. Monitoring sites in bull trout spawning areas include Big, Coal, North Coal, South Fork Coal, Whale, Trail, Swift, Granite, Goat, Squeezer, and Lion creeks. Coring sites in westslope cutthroat spawning areas are both upper and lower Hungry Horse, Margaret, Tiger, Emery, Challenge, Cyclone, and Swift creeks. Coring sites in rainbow trout spawning areas include Fish and Freeland creeks.

   C. Continue work on developing the Whitlock-Vibert box technique for sampling gravel composition. A significant relationship exists between substrate samples collected using these boxes and McNeil core samples taken at box planting sites. However, more work is required before the W-V boxes can replace coring in our streambed sampling program.

   D. Continue bull trout spawning site surveys in areas recommended for annual monitoring in Flathead River and Swan River tributaries.

   E. Select and monitor fish population statistics in an undeveloped watershed on a long-term basis. This stream should support both westslope cutthroat and bull trout and would provide better information on "natural fluctuations."

2. Future Data Needs

A. Identify sediment sources contributing to high levels of fine material existing in other critical westslope cutthroat and bull trout spawning areas. Specifically, the Big Creek drainage should be surveyed in light of current substrate composition. A detailed sediment source analysis appears to be an excellent method to asses natural and management-related effects.

B. Determine the frequency distribution and effect of woody debris on Flathead Forest streams. Debris is know to play an important role in maintaining natural pool to riffle ratios, retention of organic matter and sediments, and forming fish habitat. A cover variable may be significantly correlated with westslope cutthroat trout density.

C. Investigate winter rearing habitat for both westslope cutthroat and juvenile bull trout. It is possible that this may be the factor which limits fish populations in many Flathead tributaries.

D. Collect samples for genetic analysis from streams where this information is not currently available. We should try to document all pure strain westslope cutthroat trout populations and test juvenile bull trout populations which occur in sympatry with eastern brook trout.

E. Identify major spawning areas used by migratory westslope cutthroat trout.

F. Test habitat enhancement efforts in streams where channel stability is greater than in the South Fork of Coal Creek.

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